Vol. 15 No. 1 (2024) 10-14

Jurnal Riset
Teknologi Pencegahan Pencemaran Industri

Journal homepage: https://www.jrtppi.id

Ceramic Membrane Made from Clay and Kaolin with a Mixture of Coconut Shell Activated Charcoal as a Groundwater Filter

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ARTICLE INFO

Article history:
Received September 23, 2023
Received in revised form March 01, 2024
Accepted April 15, 2024
Available online May 31, 2024

Keywords:
Ceramic Membranes
Coconut Shell Activated Charcoal
Cleanwater
Fe
Mn

ABSTRACT

Groundwater if the quality is not good if consumed will have an impact on health. The causes of poor groundwater quality include the value of Fe and Mn levels that exceed the established quality standards. Many methods can be done to overcome the quality of groundwater caused by high Fe and Mn levels, one of which is to use a ceramic membrane made from clay and kaolin with a variation of the coconut shell activated charcoal mixture in the composition of the ceramic membrane by 5%. 10% and 15%. The goal is to determine the effect of ceramic membranes with continuous flow systems on reducing content in clean water. Results showed that the percentage of decrease in Fe and Mn content produced by variations in the composition of coconut shell activated charcoal of 0%, 5%, 10%, and 15% was, respectively for average Fe levels of 15.85%, 69.44%, 75.02%, and 80.83%, and for average Mn levels of 0.00%, 5.71%, 10.00%, and 18.67%. The best variation in the composition of coconut shell-activated charcoal in clay and kaolin-based ceramic membranes in reducing Fe and Mn content in clean water to meet the quality standards of coconut shell-activated charcoal composition by 15%. It is expected that this activity can be used as a basis for further development in groundwater treatment using ceramic membranes made from clay and kaolin with the addition of coconut shell-activated charcoal composition.

1. INTRODUCTION

Groundwater treatment using membrane technology is expected to help the community solve the clean water problem. Groundwater is one of the very important natural resources for human life and health, both meeting daily needs and serving other benefits. However, the need for water is not balanced with public awareness to preserve it so many clean water sources are polluted by human negligence, so their negligence causes water to become dirty and polluted. With the clean water crisis, it is necessary to strive for the discovery of polluted water treatment so that it is suitable for use for daily needs.

The people of Bandung today often encounter problems with clean water quality in fulfillment of their needs. The development of clean water treatment continues to expand to overcome water pollution to meet quality standards and not pose a danger to human health. Clean water treatment in Indonesia is currently treated conventionally. Clean water treatment by conventional means is carried out by Coagulation-Flocculation, Sedimentation, and Filtration. In general, conventional processing requires a large land area and complicated maintenance, but water quality is still below standard (Meidinariasty et al., 2019).

In this activity, a new technology for clean water treatment was developed, namely using membrane technology. This Membrane technology is clean and environmentally friendly. Expected that with the use of membrane technology for clean water treatment, the results obtained can meet the clean water quality standards set in Indonesia, by the Decree of the Minister of Health No.907 / MENKES / SK / VII / 2002. This membrane technology

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doi: https://10.21771/jrtppi.2024.v15.no.1.p10-14

Accreditation number: (Ristekdikti) 158/E/KPT/2021

can remove organic and inorganic compounds in water without using chemicals during operation (Wenten & Kresnowati, 2020). This enterprise's efforts in the field of clean water treatment are based on the use of ceramic membrane technology made from coconut shell-activated carbon. Ceramic membranes belong to inorganic membranes, which have advantages when compared to other membranes, such as polymer membranes and liquid membranes. The advantage is that ceramic membranes have resistance to heat, acids, and bases. Ceramic membrane raw materials include clay, quartz, and alumina. Pore-forming materials in addition to organic materials such as carbon and calcium carbonate, also organic materials such as rice flour, potatoes, and corn (Manohar, 2012). In addition to clay and zeolite used as materials to make ceramics, coconut shell charcoal is used as an additive to increase pores. Coconut shell charcoal as an alternative raw material is illustrated in large quantities found in the West Java region. Coconut shell charcoal contains 21-26% silicate, 35-45% lignin, and 2343% cellulose. In addition to these ingredients, there are other ingredients including CaO, MgO, Al2O3, and NaO. Coconut shells are the best raw materials that can be made into activated carbon because activated carbon made from coconut shells has many pores, low ash content, high water solubility, and high reactivity. Activated carbon made from coconut shells can be used as one of the raw materials, to make porous ceramics (Pambayun, et al., 2013). In research conducted by (Nainggolan, 2008) on the manufacture of porous ceramics with coconut shell additives as motor vehicle exhaust gas filters with feldspar, clay, and quartz base materials using combustion temperatures at 1000 ° C, resulting in porosity of 48.98%, burn shrinkage between 1.09% - 2.47%, the density of 1.015 grams / cm^3 and the hardness value is 102 kgf / mm^2.

Synthesis and characterization of porous ceramics based on clay and kaolin by authoring coconut shells at temperatures of 600 ° C with temperatures of 900 ° C, 950 ° C, and 1000 ° C obtained volume shrinkage of (1.60-10.14)%, mass shrinkage (13.56-20.92)%, porosity (26.16-45.33) % and density value of (1.230-1.619) gr/cm^3 (Siagian & Hutabalian, 2012). According to (Sebayang, Muljadi, & Tetuko, 2009) pottery ceramics have been made based on solid waste from the pulp and clay industries with various compositions (in mass percentage), the optimal composition is 50% solid waste from the pulp industry (sludge) and 50% clay with a sintering temperature of 900°C maintained for two hours. Under these conditions, apparent density = 1.37 g/cm^3, crystal density = 2.71 g/cm^3, porosity = 39.26% and compressive strength = 62.9 kgf/cm^2. In principle, pore-forming materials are materials that are easily burned out during the combustion process. Research on peat water conducted by (Darmayanti, Putri, & HS, 2022) by varying the material composition and burning temperature of ceramic membranes with the composition of clay materials: fly ash (60:40; 50:50; 40:60 %) and combustion temperature (750; 800; 850 ^{o}C. The best material composition and combustion temperature are obtained at a composition of 50:50% and a temperature of 850 oC with the efficiency of color removal and organic substances produced respectively of 98.70% and 94.35%. Based on studies that have been conducted by several researchers, this study will use coconut shell charcoal as a pore-forming material. The process of making this ceramic membrane is through press printing. Making membranes in this way requires a mixed condition of membrane-forming materials that are slightly wet or contain only a small amount of water. The use of ceramics itself as a membrane has been developed for microfiltration, ultrafiltration, and gas filtration processes (Ciora & Liu, 2003).

The purpose of this study was to determine the effect of ceramic membrane filtration on the quality of groundwater quality standards, determine the effect of variations in the composition of coconut shell activated charcoal mixture on ceramic membranes from clay and kaolin base materials on reducing Fe and Mn content in groundwater and determine the efficiency of activated coconut charcoal composition mixture on ceramic membranes from clay and kaolin based materials on decreasing Fe and Mn content in groundwater. The coconut shell was chosen because it is a local material and is often found in our country as agricultural waste. This is in line with the statement put forward by (Abdullayev, et all, 2019) which states that to overcome the challenges of large-scale water treatment, there is increasing interest in the fabrication and application of low-cost ceramic membranes based on natural raw materials and waste products.

2. METHODS

This research activity is an examination of field experiments that study the effect of the composition of coconut shell-activated charcoal particles mixture on ceramic membranes on reducing Fe and Mn content in clean water. The design used in this study was a post-test without control. The activity design used is a completely random design by looking at unidirectional variable relationships. The activity was carried out at the Department of Environmental Health, Polytechnic, Health, Ministry of Health, Bandung.

The population is all groundwater in the Antapani area of Bandung City. The sample is a portion of the groundwater.

The sample size is calculated based on the number of treatments, types of treatments, and the number of repetitions in the study. Using a complete randomized design formula and using 3 kinds of treatment of activated charcoal mixture composition (25, 35, and 45%) obtained 6 repeats with control. Groundwater examination parameters are Fe and Mn levels so the number of samples is 36 samples.

The materials used for the manufacture of ceramic membranes such as kaolin, and clay from Sukabumi, are finely ground using mortar and stamper. Once smooth, the ingredients are filtered with a 200-mesh sieve. Filtering here aims so that the size of the ceramic material grains is a homogeneous mixture, so as not to interfere with the results or subsequent processes.

After the ingredients are filtered, they are then composed into (w/w) 20% kaolin and 80% clay. Then coconut shell activated carbon is added as a mixture of membrane-making materials for the adsorption process to occur in addition to the ultrafiltration process on ceramic membranes, with a composition of 0%, 15%, 10%, and 15% respectively. The content of kaolin remains at 20%, while the composition of clay follows the addition of the composition of coconut shell-activated charcoal.

The materials that have been mixed are then printed with a press press,

Hydraulic Press NSP-5, with a pressure of 200 kg/cm^2 into a ceramic membrane.

After molding, the ceramic membrane is burned by oxidation at 1100°C. The ceramic membrane obtained is then tested for permeability and porosity to water and flexural strength tests. The process of making ceramic membranes is all carried out in collaboration with Balai Besar Keramik (BBK) Bandung. Furthermore, testing was carried out on the decrease in Fe and Mn levels in clean water derived from groundwater in the Bandung region.

Data is processed using software processing and data analysis. Checking data completeness, coding variables, and data input on data processing software. Data analysis was carried out univariable and bivariable. Univariable analysis presents the value of central tendency and measures of variability from dependent data, namely Fe and Mn levels of groundwater in the form of mean values, standard deviations, and minimum and maximum values. Bivariate analysis to see the effect of the variable mixture of coconut shell activated carbon on the ceramic membrane on reducing Fe and Mn levels, statistical tests began with conducting a normality test and homogeneity of data, then followed by the Manova test.

3. RESULT AND DISCUSSION

The determination of the Antapani area as a location for groundwater extraction to be used as the object of research is based on the results of preliminary groundwater surveys in several locations on its Fe and Mn levels. The levels possessed by groundwater originating from the Antapani region that do not meet the quality standards of Fe and Mn levels are as follows: 3.7 mg / l and Mn spread: 0.7 mg / l.

The presence of Fe and Mn in groundwater is caused by the condition of rocks in the aquifer layer in the soil, where the higher the Fe and Mn levels in the rocks and soil in the aquifer layer, the higher the Fe and Mn levels in the groundwater. Iron (Fe) exists in soil and rock as ferric oxide (Fe_2O_3) and ferric hydroxide ($Fe(OH)_3$). In water, iron takes the form of ferrobicarbonate ($Fe(HCO_3)_2$), ferrohydroxide (Fe(OH), ferrosulfate ($FeSO_4$), and complex organic iron. Groundwater contains Fe dissolved iron (Fe^{2+}). Mn (Mn) resides in soil and rock as MnO_2, Mn_3O_4 or $MnCO_3$. Groundwater contains dissolved manganese in the form of mangano (Mn^{2+}).

The results of the characterization of ceramic membranes with variations in the composition of coconut shell activated charcoal in terms of porosity, density, water absorption, and bending strength can be seen in Table 1 below:

Table 1. Characterization of ceramic membranes seen from the average Porosity, Density, and Water Infiltration

Ceramic membrane with Charcoal Content active	Weight in water Ba (gr)	Heavy Wet Bb (gr)	Berat Kering Bk (gr)	Bb-Bk (gr)	Bb-Ba (gr)	Bk-Ba (gr)	Porosity P (%)	Density D (gr/ cm3)	Infiltration water PA (%)
0%	20.23	34.28	31.18	3.1	14.05	10.95	22.11	2.85	9.04
5%	5,67	33,23	25,7	7,53	27,57	20.03	27,38	1.28	22,69
10%	3,07	38,27	28,437	9,837	35,20	25.37	27,84	1.12	25,614
15%	3,77	32,27	22,137	10,13	28,50	18.37	35,54	1.20	31,39

From Table 1. Above, the porosity and absorption of water in the ceramic membrane tend to be greater in line with the increase in the composition of coconut shell activated charcoal on the ceramic membrane, while the density tends to decrease in value in line with the increase in the composition of coconut shell activated charcoal on the ceramic membrane.

Data on ceramic membrane characteristics for flexural strength parameters can be seen in Table 2. below:

Table 2. Characterization of ceramic membranes seen from the average bending strength

Ceramic membrane with Activated Charcoal Content	Wide b (cm)	High h (cm)	Big Force, P (kN)	Weight point, L (cm)	Flexible strength, Fb (Kgf/cm²)	Flexible strength, Fb (Mpa)
0%	2,06	0,99	174,33	10	1294,44	126,98
5%	2,23	1,20	160	10	756,45	80,432
10%	2,19	1,11	147,33	10	819,90	74,21
15%	2,33	1,16	143,33	10	693,93	68,07

Bending strength is the ability of a concrete block placed on two layings to withstand a force with a direction perpendicular to the axis of the specimen, which is applied to it, until the specimen breaks and is expressed in Mega Pascals (MPa) The force per unit area. From the data in Table 2. Above it can be seen that the value of flexural strength will decrease in line with the increase in the composition of coconut shell-activated charcoal on the ceramic membrane.

Data on reducing Fe and Mn levels using ceramic membranes can be seen in Table 3. below:

Table 3. Data on Fe and Mn levels decrease

Repetition ke	Initial levels of Fe and Mn in water soil (mg/l)		Fe and Mn (mg/l) levels in groundwater after passing through a ceramic membrane with a mixture of coconut shell activated charcoal							
			0%		5%		10%		15%	
1	Fe	Mn	Fe	Mn	Fe	Mn	Fe	Mn	Fe	Mn
2	2,9	0,6	2,6	0,6	0,8	0,6	0,6	0,5	0,1	0,4
3	2,4	0,6	2,0	0,6	0,9	0,6	0,6	0,5	0,1	0,4
4	2,8	0,7	2,3	0,7	0,8	0,6	0,5	0,6	0,2	0,5
5	3,1	0,7	2,6	0,7	0,8	0,6	0,6	0,6	0,2	0,5
Average	2,7	0,6	2,3	0,6	0,9	0,6	0,6	0,5	0,2	0,4

From the data in Table 3. above it can be seen that the composition of a mixture of coconut shell-activated charcoal on clay-based ceramic membranes and kaolin which is effective for reducing Fe and Mn levels in groundwater occurs in variations in the composition of coconut shell-activated charcoal by 15%.

The data in Table 3 above when calculating the average percentage of Fe content reduction for coconut shell activated charcoal composition of 0%, 5%, 10%, and 15% are respectively 15.85%, 69.44%, 75.02%, and 80.83%. The average percentage of reduction in Mn content for coconut shell activated charcoal composition of 0%, 5%, 10%, and 15% was 0.00%, 5.71%, 10.00%, and 18.75% respectively.

The characteristics of ceramic membranes for porosity, density, and water absorption in this activity when compared to research(Kurniawan, Budi, & Susilo, 2014) can be seen in Table 4. below:

Table 4. Comparison of Porosity, Density, and Water Infiltration Data

Ceramic membrane with Activated Charcoal Content	Composition of Clay membrane and Kaloin in this study with shell-activated charcoal coconut as part of the composition membrane			Composition of Clay membrane and Zeolite with coconut shell activated charcoal as an additive to enlarge porosity, (Kurniawan et al., 2014)		
	Porosity	Porosity	Water absorption	Porosity	Density	Water absorption
	P (%)	D gr/cm3)	PA (%)	P (%)	D (gr/cm3)	PA (%)
0%	22.11	2.85	9.04	21.701	0.953	19.802
5%	27,38	1.28	22,69	26.243	0.845	27.033
10%	27,84	1.12	25,614	26.901	0.750	31.192
15%	35,54	1.20	31,39	28.942	0.711	35.43

From the data in Table 4. above it can be seen that the density value is different because in this study carbon as a mixer is not charred/lost while in research conducted by (Kurniawan et al., 2014) carbon as an additive is lost and burned in the heating process, so the density tends to be smaller than this activity. The data on porosity and water absorption do not differ much.

The decrease in Fe and Mn levels by the ceramic membrane occurs due to the composition of coconut shell-activated charcoal on the ceramic membrane so the process that occurs is not only the microfiltration process but also the adsorption process. When viewed from the average value of the percentage of decline, it can be seen that the average percentage decrease in Fe levels is greater than the average value of the percentage decrease in Mn levels in groundwater produced by this ceramic membrane. This is likely due to relatively low initial levels of Mn, which is an average of 0.6 mg / l so the efficiency is higher than Fe levels. This is in line with the results of (Nevyana, 2019) where the adsorption process using manganese greensand the efficiency of reducing Mn is around 23.00% with an initial level of Mn 0.5 mg / l and a flow speed of 2.5 ml/minute then the efficiency rises to 55% and 61.92% with initial levels of Mn 1.1 and 1.3 mg / l.

4. CONCLUSION

The percentage reduction in Fe content for coconut shell activated charcoal compositions of 0%, 5%, 10%, and 15% is 15.85%, 69.44%, 75.02% and 80.83% respectively. The average percentage reduction in Mn content for coconut shell-activated charcoal compositions of 0%, 5%, 10% and 15% is 0.00%, 5.71%, 10.00% and 18.75% respectively. The decrease in Fe and Mn containt is due to the adsorption process in the ceramic membrane due to the composition of the coconut shell-activated charcoal mixture.

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